Dual-Point Impedance Control for Telerobotics

Technology Need:

Radioactive tank waste remediation, deactivation and decommissioning (D&D) of contaminated Department of Energy (DOE) facilities, and other nuclear cleanup tasks will require extensive use of remote handling technologies. The unstructured nature of these tasks and limitations of the current sensor and computer decision-making technologies prohibit the use of completely autonomous systems for remote manipulation.

Teleoperated systems, or those in which humans are an integral part of the control, are currently used for performing these tasks. However, these systems are difficult to operate and make simple manipulation operations tedious and time consuming, thus increasing costs and contributing to operator fatigue.

Technology Description:

The University of Tennessee (UT) has developed a methodology to incorporate sensor and model based computer assistance into human controlled teleoperator systems. In this approach, human operator input is enhanced, but not superseded by the computer. This form of assistance can be provided by adjusting system parameters that are not under direct control by the operator, such as impedance parameters and workspace mappings between the master and slave manipulators. Such supervisory control is different from (but can coexist with) traded control, where the human from time to time relinquishes control to the computer or shared control. Using supervisory control, the human may act as a supervisor to control some variables and direct controller for other variables. A photograph of the system being developed is pictured in Figure 1.

The basic approach is to use available, but incomplete and imperfect, sensory and model data to assist the operator's motions, while the operator retains direct control of the manipulator. Since the operator always maintains direct control, autonomous computer control is not necessary.

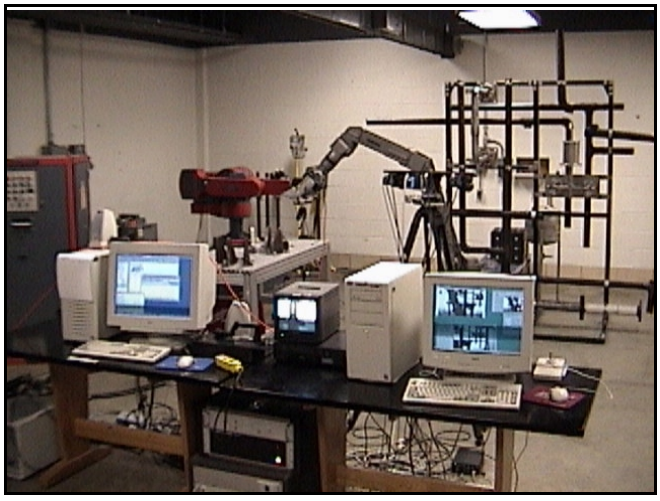

Figure 1: Dual Point Impedance Control System

A telerobotic controller has been developed that incorporates sensory and model information to assist the human operator. This is accomplished through intelligent mapping of the master commands to the remote manipulator motion. It can also adjust the dynamics parameters of the remote manipulator based on the sensory and model inputs. The initial features of this controller were implemented on a testbed consisting of a seven-degree-of-freedom Robotics Research Corporation manipulator and a six-degree-of-freedom force reflecting Kraft hand controller. The sensor suite consists of a vision system, laser range finder, force/torque sensors, and ultrasonic sensors. This work was transitioned to a testbed based on an electrohydraulic manipulator system (Schilling Titan II) commonly used in remote operations.

The types of assistance expected to be offered by this technology include optimal trade-offs in workspace volume and motion resolution; avoidance of hard impacts; assistance in tool alignment with precision

tasks; obstacle avoidance, and automatic adjustment of dynamics parameters to suit working conditions.

UT studied computer-assisted teleoperation in the context of the Modified Light-Duty Utility Arm (MLDUA) at ORNL. An overall telerobot concept that integrates manual teleoperation, computer assisted teleoperation and autonomous computer-controlled operation was created. Integration of the overall controller, including computer assist functions, with the Dual Arm Telerobotics test bed at ORNL is ongoing and will be used to verify operability with respect to several D&D needs.

Benefits:

▸Increased efficiency and lower costs: The system allows faster performance of such tasks as attaching different tooling to the MLDUA, avoiding obstacles, precise positioning, drilling, sawing, and unbolting.

▸Improved safety: Sensor assistance would result in safer teleoperation due to obstacle avoidance and reduction in impact forces during contact.

▸Lower operator fatigue: By making it easier to accomplish tasks, significant reductions in operator fatigue are expected.

Status and Accomplishments:

UT developed and implemented the baseline architecture and control algorithms for dual-point impedance, linear, planar, and force-constrained control. UT tested the architecture using computer simulations and implemented the control algorithms on the laboratory system. This work was integrated with the ORNL Pit Riser Project, developed for telerobotic operation. Integration of the completed system elements is ongoing. This work is being coordinated with the Robot Task Space Analyzer (TMS# 2171), which was also completed at UT. The system is being integrated with the ORNL dual arm telerobotic test bed for further study under realistic cold test conditions. Development of a prototype robot task space scene analysis sensor head will provide a robust sensor capability for the ORNL dual arm telerobotic test bed necessary to fully evaluate computer assisted teleoperation.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 2173
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

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